Coastal Engineering Technical Note

MONITORING COMPLETED COASTAL PROJECTS - LESSONS LEARNED II

PURPOSE: To provide a summary of lessons learned from the Monitoring Completed Coastal Projects (MCCP) Program.

GENERAL: This CETN is the second in a series summarizing lessons learned from the MCCP Program. It covers five projects for which reports have been completed: East Breakwater Rehabilitation at Cleveland Harbor, Ohio (Pope, et al., 1992); Fisherman's Wharf Breakwater, San Francisco, California (Lott, 1993); Barbers Point Harbor, Hawaii (Lillycrop, et al., 1993); Rehabilitation of the South Jetty - Ocean City, Maryland (Bass, et al., 1993); and Beach Erosion Control Project at Oakland Beach, Rhode Island (LeBlanc and Bottin, 1992). These projects covered four general areas: breakwaters; a jettied inlet; harbors; and a beachfill.

INLETS: One tidal inlet through a barrier island, at Ocean City, Maryland, was monitored. This included monitoring the inlet for shoaling, the Assateague Island beaches south of the inlet, and beaches within the inlet, in conjunction with sealing the south jetty to prevent the passage of sand into the inlet (Bass, et al., 1993). Lessons learned are summarized as follows:

1. Construction of jetties caused establishment of a new equilibrium for the inlet - ebb tidal delta system. Bathymetric measurements over the shoals and surveys along adjacent shorelines are required over an extended time period to establish the new equilibrium. This was also a previous finding of Morang (1992). When an equilibrium state is reached, natural bypassing may resume via the ebb tidal delta.

2. Sealing the south jetty to prevent passage of sand was effective in preventing shoaling in the inlet. The effectiveness of sand sealing to prevent shoaling was also a previous finding of Gebert and Hemsley (1991).

3. The shoreline south of the jetty sometimes advanced and sometimes retreated after the sealing of the jetty. This could result from any one, or a combination, of the following effects: (a) shifts may occur in predominant wave direction and associated net littoral transport direction over longer periods of time (Morang, 1992); (b) "slugs" of material may be bypassed via the ebb tidal delta causing cyclic shoreline movement, accretion (shoreline advance) as they weld to the shoreline, and apparent erosion (shoreline retreat) as the material moves farther along the shoreline (FitzGerald, 1988), consistent with the August 1986 to December 1987 record of shoreline position; and/or (c) the beach may steepen and flatten under different wave climates, i.e., there may be "seasonal" beaches (Bass, et al., 1993). Records should be studied for extended time periods if there is any evidence of possible reversals. Single-year, or even multi-year, analysis is not sufficient (Morang, 1992).

4. Sealing of a jetty can result in erosion of a shoreline inside a jettied inlet, when that shoreline was previously nourished by sand passing through the jetty. Protective measures may be required for a shoreline inside a jettied inlet concurrent with sealing a jetty.

5. Average shoreline configuration between segmented "headland" breakwaters, used to prevent shoreline erosion, can be generally predicted based on empirical understandings, considering the combined effects of tidal currents and variations in wave conditions.

6. Filling a scour hole at the end of a jetty and covering the area with a layer of armor stone is effective in preventing further scouring. The need for stone aprons is also discussed by Morang (1992) and Lott (1993)

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<u>HARBORS:</u> Harbors were monitored at Barbers Point, Hawaii (Lillycrop, et al., 1993), and Fisherman's Wharf, San Francisco, California (Lott, 1993). Lessons learned are:

7. A combination of numerical and physical models is recommended for investigating the full range of wave conditions in a harbor (Lillycrop, et al., 1993). The numerical model predicts very long period resonant modes (i.e., longer than 400 sec) better than the physical model, and provides reasonably accurate solutions for these resonant modes of a harbor (Lillycrop, et al., 1993; Lott, 1993). The physical model more accurately predicts the shorter period wind waves.

8. When collecting data in the field, sampling rates (both frequency of gage polling and frequency of pressure sampling within bursts) should be specifically tailored to the frequency regimes present (Lott, 1993).

9. Rubble mound wave absorbers effectively reduce wave energy inside the harbor for wind wave periods of 20 seconds or less (Lillycrop, et al., 1993). These waves were reduced approximately 50 percent at some locations in Barbers Point Harbor. The wave absorbers are not effective, however, in damping resonant wave modes, i.e., modes greater than 50 seconds in the case of Barbers Point Harbor.

10. The longer-period resonant wave modes of a harbor are a function of the harbor shape and dimensions. There is no effective means of damping out resonant wave modes after a harbor is contructed. Numerical and physical models should be used during initial harbor planning to ensure undesirable modes, e.g., modes that will match natural periods of ships, will not occur in the constructed harbor.

11. As waves travel into harbors from deep water, nonlinear processes transfer energy from the wind-wave frequencies to long waves with periods of several minutes. If the periods of these long waves correspond with the natural resonant modes of a harbor, seiching may occur. Some of this long period energy is in the infragravity wave band (periods from 25 to 200 sec). Infragravity wave heights outside the harbor increase as swell energy increases. Since infragravity energy inside the harbor is highly correlated with infragravity energy outside the harbor, an increase in swell energy may cause an increase in infragravity wave heights inside the harbor (Lillycrop, et al., 1993).

12. Free long waves generated from distant sources are not an important forcing mechanism in Barbers Point Harbor. It was also determined that while a drop in atmospheric sea level pressure could cause wave height increases in the harbor, this is an infrequent occurrence in Hawaii and is not the major contributor to wave heights in Barbers Point Harbor.

13. Addition of a small boat harbor connected to the main harbor a Barbers Point resulted in a slight shift of resonant frequencies of the main harbor to lower frequencies (longer periods). This would be expected as the effective length of the harbor increased with the addition of the marina.

<u>BREAKWATERS</u>: A breakwater rehabilitation was monitored at Cleveland Harbor, Ohio (Pope, et al., 1993). In addition, vertical wall breakwaters were monitored at Fisherman's Wharf, San Francisco, CA (Lott, 1993). Lessons learned are:

14. When concrete armor units are placed on an impermeable base, e.g., against a concrete structure, reflected wave energy from the impermeable base appears to cause armor units to "pop out" of the armor layer. Consequently, the width of the armor layer may need to be increased from a two-unit width to a minimum three-unit width, to decrease the reflected wave energy (Pope, et al., 1993).

15. Armor units near the water line, in the active wave zone, are more subject to movement than units on the crest of the structure or below the active wave zone.

16. Armor units continue to settle and "pack together" for an extended period of time after placement. This can reduce movement over time, but may increase static stress in the units (U.S. Army Corps of Engineers, 1993; Kendall and Melby, 1993).

17. Use of 4,000 psi concrete instead of 6,000 psi concrete was recommended at Cleveland Harbor, along with the use of steel rebar reinforcement concentrated

in the fluke-stem joint. A Buffalo District report noted that there is a persuasive argument that the higher strength concrete tends to be more prone to shrinkage and thermal cracking, and is also more brittle, all of which reduce the effective tensile strength of the material. However, higher strength concrete was used at Humboldt and Crescent City without any of these problems (Kendall and Melby, 1989).

18. Hydraulic model studies are recommended to determine the required size of armor units. Post-construction model studies of the Cleveland East Breakwater indicated that the original 2-ton dolos armor units were underdesigned, and that 4-ton dolos armor units would decrease the probability of movement.

19. Fender pile clusters at the ends of breakwaters experience substantial motion, with lateral excursions up to several feet (Lott, 1993). Some piles within the clusters at Fisherman's Wharf uplifted several inches, and connections between piles have become loose. Fender pile clusters will need periodic maintenance where they are used.

20. In some locations on the Fisherman's Wharf breakwater, grout patches had fallen off allowing some minor corrosion to sheet pile edges. Also, some rubber expansion joint gaskets have loosened from the underside of the detached breakwater cap. These require maintenance.

21. Scour prediction methods were reasonably accurate in identifying locations of scour and deposition at Fisherman's Wharf, but less successful in predicting magnitudes, which were both under- and over-predicted. Scour occurred in such areas as the west end of the detached breakwater. Scour depths exceeded 10 feet in some locations (Lott, 1993).

22. Placement of indestructible survey monuments in structures as reference points for surveys was very helpful at Fisherman's Wharf, and is highly recommended at all project sites.

23. Breakwater structures at Fisherman's Wharf did not sustain damage from the Loma Prieta earthquake in October 1989.

<u>BEACHFILLS:</u> A beachfill was monitored at Oakland Beach, Rhode Island (LeBlanc and Bottin, 1992). Lessons learned are:

24. There is a general trend of erosion (offshore movement) during storm conditions, and accretion (onshore movement) during mild wave conditions, similar to what is found on the open ocean coast.

25. Careful placement of profile lines is required for shorelines that are scalloped, e.g., where sand accumulates at groins. Linear interpolation between survey lines can give a misleading picture of the three-dimensional beachface.

26. Use of fill material coarser than the native material appeared to result in better retention of the beachfill.

27. Presence of foreign material, e.g., glass fragments, on the beach can bias grain size analysis.

28. Material at Oakland Beach will eventually be lost around the terminal groin unless the beach is periodically reshaped.

29. Beaches that have winter ice cover may be protected from erosion during the winter storm season.

30. The SPM method for adjusting winds measured over land to a site on the coast should be used with care in areas not similar to the Great Lakes regime where it was developed. Otherwise, winds at the coast may be over or under-predicted.

<u>ADDITIONAL INFORMATION</u>: Contact Dr. Fred E. Camfield at (601) 634-2012 or Ms. Carolyn Holmes, Program Manager, MCCP, at (601) 634-2025, FAX (601) 634-2055.

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